TUBULAR BUSBAR CLAMPS IN ALUMINIUM ALLOY

INTRODUCTION

The aluminium alloy tubular bus current carrying clamps depicted in this section are manufactured in certified aluminium alloys, namely aluminium alloy grade LM-6 as a standard, alternatively in aluminium alloy LM-25 heat treated to a T6 temper where a clamp is required to comply with a higher strength rating.

Tubular Busbar

Standard South African busbar tubes are supplied in either the alloys 6101-A and/or 6261-TF which are both suitable for electrical purposes. The 6261-TF alloy has better mechanical properties, but somewhat poorer electrical properties than the 6101-A. However, for application of HV yards, where long spans are essential, the 6261-TF alloy with superior mechanical properties is preferred. All imported Aluminium Alloy Tubular Busbar are in the grade 6101-BT6.

Alloy Type	Max Yield Strength MPa	Electrical Resistivety at 20°C in mm^2/m
6101-A	170	0.03133
6261-TF	240	0.037
6101-BT6	160	0.0333

Standard Tubular Busbar

Outer Diameter	Wall Thickness	Cross Section	Weight	Permanent Electrical Load		± Tolerance in outer diameter incl. deviation from roundness	Max. Length which can be supplied	Maximum sag (cm) due to own weight, 2 supports, (for 3 supports multiply listed values by 0.415)												
				Busbar Temp.				Support spacing (m)												
mm	mm	mm²	kg/m	65°C A	85°C A	mm	m	6	8	10	12	14	16	18	20	22	24	26	28	30
80	4	955	2.58	1,400	1,860	0.6	19	0.9	2.8	6.8	14.1	26.1								
	5	1,178	3.18	1,560	2,070	0.6		0.9	2.9	7.0	14.4	26.8	45.6							
	6	1,395	3.77	1,690	2,240	0.6		0.9	3.0	7.1	14.8	27.5	46.8							
	8	1,810	4.89	1,920	2,550	0.6		1.0	3.1	7.5	15.5	28.8	49.1							
	10	2,199	5.94	2,110	2,790	0.6		1.0	3.2	7.9	16.4	30.3	51.8							
100	4	1,206	3.26	1,690	2,240	0.7	25	0.6	1.8	4.3	8.9	16.4	28.0							
	5	1,492	4.03	1,880	2,490	0.7			1.8	4.3	9.1	16.7	28.5	45.6						
	6	1,772	4.78	2,040	2,710	0.7			1.8	4.4	9.2	17.1	29.1	46.6						
	8	2,312	6.24	2,320	3,070	0.7			1.9	4.6	9.6	17.8	30.3	48.75	73.9					
	10	2,827	7.63	2,540	3,360	0.7			2.0	4.8	9.9	18.4	31.4	50.3	76.7					
120	4	1,458	3.94	1,950	2,580	0.7	25	0.4	1.2	2.9	6.1	11.3	19.2	30.8						
	5	1,806	4.88	2,170	2,880	0.7			1.2	3.0	6.2	11.4	19.5	31.2	47.6					
	6	2,149	5.80	2,370	3,140	0.7			1.2	3.0	6.3	11.6	19.8	31.7	48.3					
	8	2,815	7.60	2,700	3,580	0.7			1.3	3.1	6.5	12.0	20.4	32.7	49.9	73.1				
	10	3,456	9.33	2,960	3,920	0.7			1.3	3.2	6.7	12.4	21.1	33.9	51.6	75.6				
	12	4,072	10.99	3,130	4,150	0.7			1.4	3.3	6.9	12.8	21.8	35.0	53.3	78.0				
150	4	1,835	4.95		2,900	1.0	25			1.9										
	6	2,714	7.33		3,500	1.0				1.9										
	8	3,569	9.64		4,000	1.0				2										
160	4	1,960	5.29	2,520	3,330	1.0	25	0.2	0.7	1.6	3.3	6.2	10.6	16.9	25.9	37.8				
	5	2,435	6.57	2,790	3,700	1.0				1.6	3.4	6.3	10.7	17.2	26.2	38.3	54.3			
	6	2,903	7.84	3,060	4,050	1.0				1.7	3.4	6.4	10.9	17.4	26.5	38.3	55.0			
	7	3,365	9.08	3,270	4,330	1.0				1.7	3.5	6.4	11.0	17.6	26.8	39.3	55.6			
	8	3,820	10.31	3,490	4,630	1.0				1.7	3.5	6.5	11.1	17.8	27.2	39.8	56.4			
	10	4,712	12.72	3,830	5,070	1.0				1.7	3.6	6.7	11.4	18.3	27.9	40.8	57.8			
	12	5,579	15.06	4,060	5,380	1.0				1.8	3.7	6.9	11.7	18.7	28.5	41.8	59.2			
200	4	2,463	6.65	3,030	4,010	1.2	25	0.1	0.4	1.0	2.1	3.8	6.7	10.8	16.4	24.0	34.0			
	5	3,063	8.27	3,410	4,520	1.2			0.4	1.0	2.1	4.0	6.8	10.9	16.5	24.2	34.3	47.3		
	6	3,657	9.87	3,720	4,920	1.2			0.4	1.0	2.2	4.0	6.8	11	16.7	24.5	34.6	47.7	63.8	
	8	4,825	13.0	4,270	5,660	1.2			0.4	1.1	2.2	4.1	7.0	11.2	17.0	24.9	35.3	48.6	65.4	86.1
	10	5,969	16.1	4,680	6,200	1.2			0.4	1.1	2.3	4.2	7.2	11.4	17.4	25.4	36.0	49.6	66.8	88.0
	12	7,087	19.1	4,990	6,610	1.2			5.0	1.1	2.3	4.3	7.3	11.6	17.7	25.9	36.7	50.6	68.0	89.6
250	5	3,848	10.4	4,140	5,490	1.5	25	0.1	0.3	0.7	1.4	2.5	4.3	6.9	10.5	15.4	21.8	30.0	40.3	53.1
	6	4,599	12.4	4,520	5,990	1.5	25				1.4	2.5	4.3	6.9	10.6	15.5	21.9	30.1	40.5	53.4
	8	6,082	16.4	5,190	6,870	1.5	25				1.4	2.6	4.4	7	10.7	15.7	22.2	30.6	41.2	54.3
	10	7,540	20.4	5,700	7,560	1.5	25				1.4	2.6	4.5	7.2	10.9	16.0	22.7	31.2	42.0	55.4
	12	8,972	24.2	6,100	8,080	1.5	25				1.4	2.7	4.5	7.3	11.1	16.2	23.0	31.6	42.5	56.1
	14	10,380	28.0	6,420	8,500	1.5	23				1.5	2.7	4.6	7.4	11.3	16.5	23.3	32.1	43.2	57.0
	16	11,762	31.8	6,640	8,800	1.5	19				1.5	2.8	4.7	7.5	11.5	16.8	23.8	32.7	44.0	58.0

INSTALLATION PROCEDURE

When installing full or half expansion inter-connector clamps, care must be taken for the allowance of the thermal expansion of the relevant basbar tube, be it aluminium or copper. An estimate of the expansion of various tubes due to thermal expansion at various temperature changes is given in the tables below:

1. Calculation of Thermal Expansion in Aluminium Tubes in mm

Length of Tube in Meters	Temperature Difference △T. in °C									
	10	20	30	40	50	60	70	80	90	100
2.5	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
5.0	1.2	2.4	3.6	3.0	6.0	7.2	8.4	9.6	10.8	12.0
10	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0
20	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2	48.0
30	7.2	14.4	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0
40	9.6	19.2	28.8	38.4	48.0	57.6	67.2	76.8	86.4	96.0
50	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0

Temperature Co-efficient of Linear expansion (temp. range -20° + 200°C
Aluminium: 23×10^{-6} (0,000023 per centigrade degree)

Example of the Calculation of Thermal Busbar Expansion:

Aluminium basbar tube, length = 10m

Temperature difference t = Max. Op. Temperature – Min. Op. Temperature
= (+80°C) – (-20°C)
t = 100°C
Assembly temperature = +20°C

For complete expansion length refer to table = 24.0mm.

Temperature difference between the final temperature (+80°C) and the assembly temperature (+20°C) is therefore 60°C. Referring to the above table, the corresponding expansion difference will be 14,4mm. The clamp must therefore be mounted in such a way that a shift of at least 14,4mm in the direction of the clamp centre is guaranteed. A shift in the opposite direction in accordance with the temperature difference of (+20°C) assembly temperature and (+20°C) being the lowest final temperature - 40°C. Referring to the above tables, this value is given as 9.6mm.

2. Short Circuit Forces on Clamps

Tube Size	Current Rating	Phase * Spacing	Short Circuit	Transverse Short Circuit Forces on Clamps and Post Insulators
mm	Amp	m	kA	kN
80 x 8	2 300	2.3	16	4
100 x 8	2 800	2.3	25	6
120 x 8	3 300	2.3	25	6
150 x 8	4 000	4.5	50	16
200 x 8	5 200	4.5	50	16
250 x 8	6 300	4.5	50	20

*Notes: * Indicates the phase spacing at which maximum short circuit forces occurs.*

Clamps are designed to have a factor of safety of 2:1 with respect to the specified load. Unless the min. mechanical load is specified, the standard strength LM-6 alloy clamp, is supplied.

3. Busbar Tube Vibration Damping

Aluminium tubular busbars are subject to wind-generated vibration and oscillation. Because of the low self-damping of tubular busbars very slight excitation forces will suffice to excite the tubes to vibrations amplitudes of the order of the tube diameter, when there is a resilience of the excitation force with a natural frequency of the tube. These high amplitudes produce additional dynamic stresses inside all structural parts and it is often necessary to dampen this tube oscillation by the insertion of AAC conductor into the busbar. The increased self damping provided by the insertion of damping conductor delays the onset of resilience build-up and this limits the maximum amplitudes created by a given excitation force.

As a rule it is normally sufficient to insert one conductor into a tube, but in order to increase the safety and to maintain maximum damping effect it is advisable to insert two conductors into the tube (one at each end running for 2/3 of the tube length). The following table shows recommended damping conductor sizes. A drain hole of 10mm diameter should be drilled at bottom centre point of tubes to facilitate drainage of condensate moisture.

Recommended Damping Cables		
Tube-Ø mm	**Al-cable mm**	**Permissible spacing between supports without damping cables m (nominal values)**
63	120	3.0
80	150	3.5
100	240	4.5
120	300	5.5
160	500	7.5
200	625	9.5
250	625	12.0

4. Nominal Linear Expansion of Tubular Busbars

Temperature °C	Expansion in mm/Per Meter	
	Aluminium	Copper
20	0.69	0.51
30	0.92	0.68
40	1.15	0.85
50	1.38	1.02
60	1.61	1.19
70	1.84	1.36
80	2.12	1.58